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THE LOW-ENERGY COAST AND ITS NEW SHORELINE

TYPES ON THE GULF OF MEXICO 1/

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Research conducted under the auspices of the Agricultural and Mechanical College of Texas, the A. & M. Research Foundation, the Florida Geological Survey and the Geographic Branch of the Office of Naval Research, Department of the Navy, U. S. A.

Contribution No. _____, of the Department of Oceanography, Agricultural and Mechanical College of Texas, College Station, Texas, U. S. A.

Offered to International Association for Quaternary Research, IV Congress, Rome - Pisa, August - September 1953.

THE LOW-ENERGY COAST AND SHORELINE,
A NEW GEOMORPHIC ENVIRONMENTAL TYPE

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ABSTRACT

High-energy coasts are those well known to tourists, artists, engineers and scientists because of their cliffs, caves, stacks, beaches, sandy barrier islands and ever-present breakers and surf. Low energy coasts are neglected geomorphic environments important to geologists, biologists and oceanographers in spite of their quiet waters, absence of harbors and low scenic values when seen only from the surface.

Low energy coasts from the Gulf of Mexico are described with their controlling environmental conditions. These coasts show us new types of shorelines with quiet waters across the adjacent bottoms. Where land-derived sediments are scarce on such a coast there is abundant aquatic life, and coastal and shoreline deposits and structures of organic agency are well developed. Emergent Quaternary examples of these shoreline types are noted.

Submitted July 27, 1953, to INQUA CONGRESS, ROME,
as replacement topic.

LOW-ENERGY COASTS OF PARTLY DROWNED LIMESTONE-PLATEAU PENINSULAS.

Where waves expend large amounts of mechanical energy inshore, beaches or wave-cut cliffs mark the resulting high-energy coast and shoreline. These with those of moderate energy, include virtually the only well-known shoreline types. Local low-energy environments occur below the depths of heavy wave action and on quiet lagoonal shores and bottoms. A regional development of marshy and swampy low-energy coasts and shorelines occurs on 3 gently sloping sectors of the Gulf coasts (offshore-wind side) of the drowned young karst plains of two large limestone peninsulas - for 240 statute miles in Florida and 50 in Campeche on the Yucatan peninsula (Fig. 1, No.6, Figs. 2,3).

Figure 1. Continental shelf, northern Gulf of Mexico, bottom profiles. Off beaches, Profiles 1 - 3 south Texas, 4 Central Florida; off drowned karst, Florida, Profile 6 (Price 1953). Theoretical low-energy coast (Keulegan and Krumbein 1949) Profile 7.

Figure 2. Topography and drainage, Florida peninsula. Contours: on land, feet; submarine, fathoms.

Figure 3. Yucatan peninsula. Submarine contours in fathoms. Land topography by hachures.

These 3 sectors have uneven, little-smoothed shorelines and bottoms. Across such gently sloping bottoms, waves are constantly deformed, losing energy and arriving at the shore without forming a line of breakers and without enough energy to develop a cliff or beach (4, 9) ^{2/}.

^{2/}

See References, at end of paper.

The theoretical critical bottom profile separating high- from low-energy coasts is a concave asymptotic curve in which depth varies as the $4/7$ power of distances from shore (Fig. 1, No. 7). This profile essentially coincides with the characteristically uneven bottom of the low-energy coast of

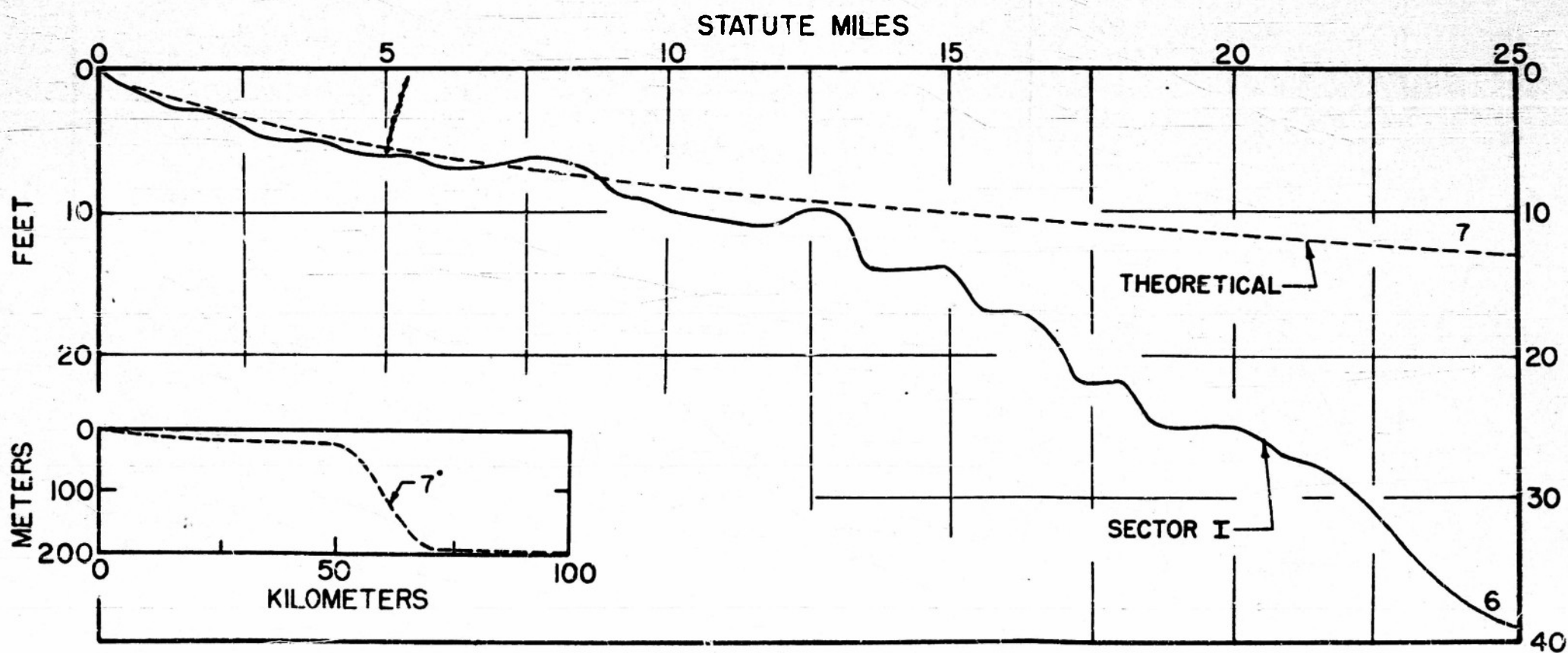
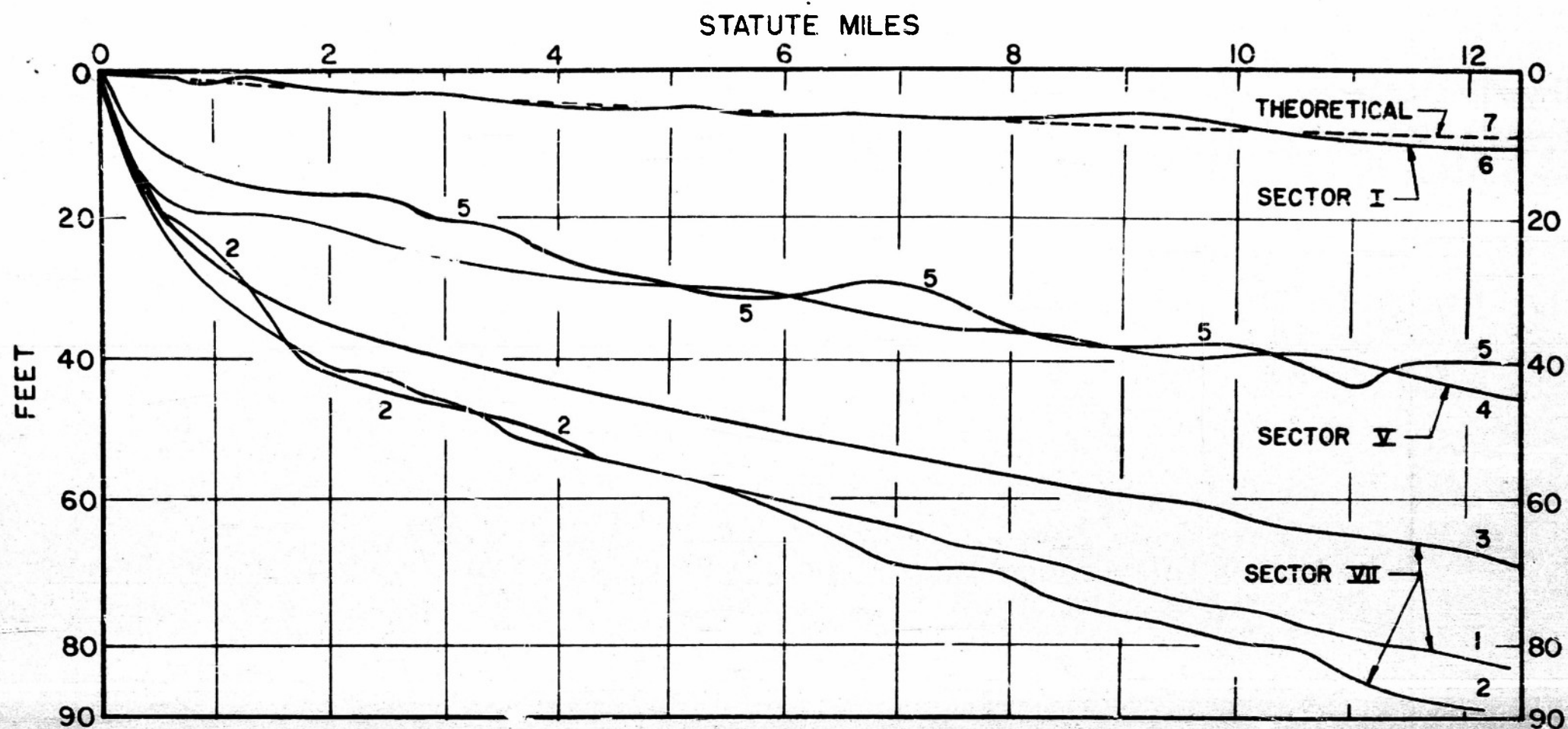
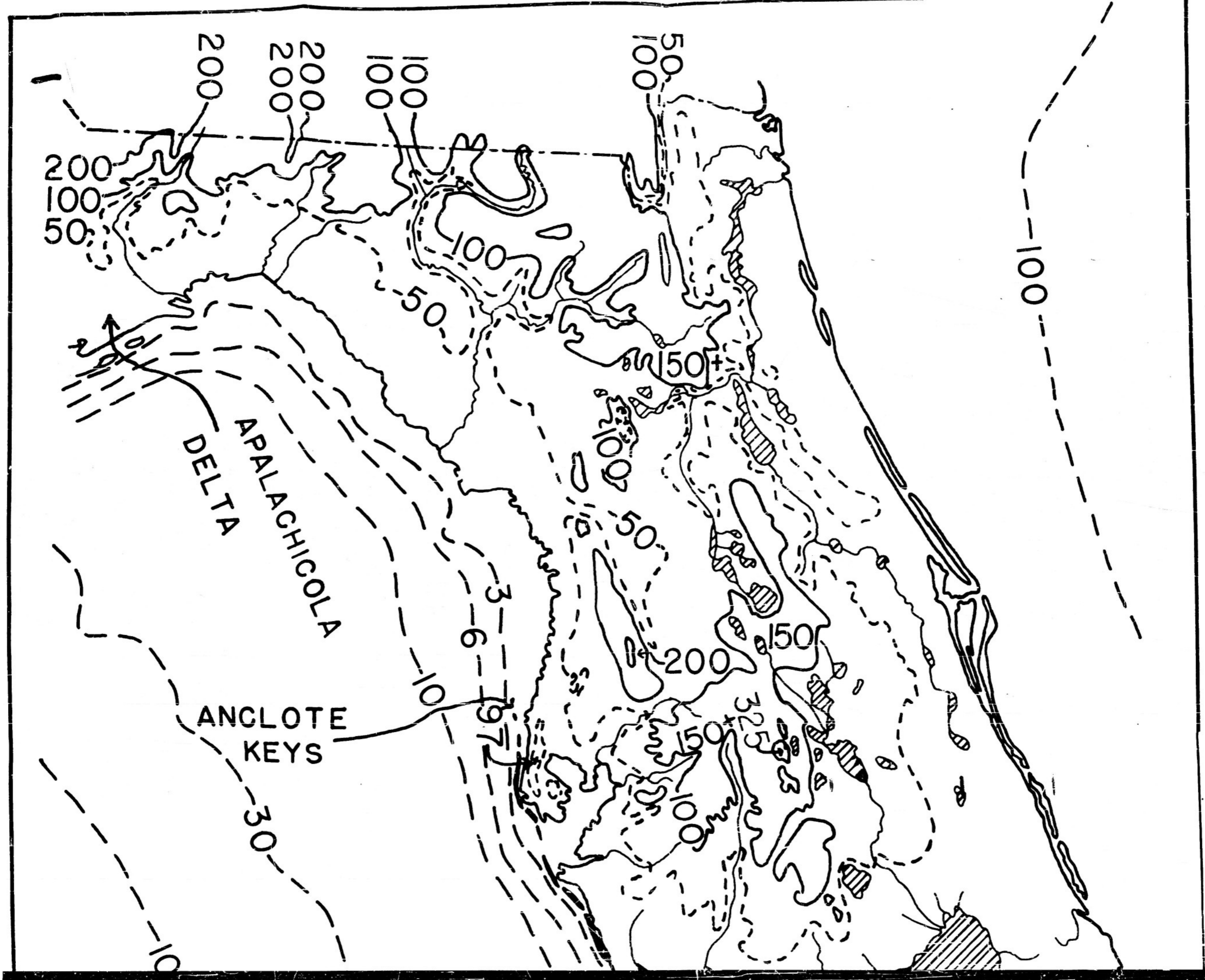


Fig. 1.



KEYS

30

100

1000

100

150

BIG
CYPRESS

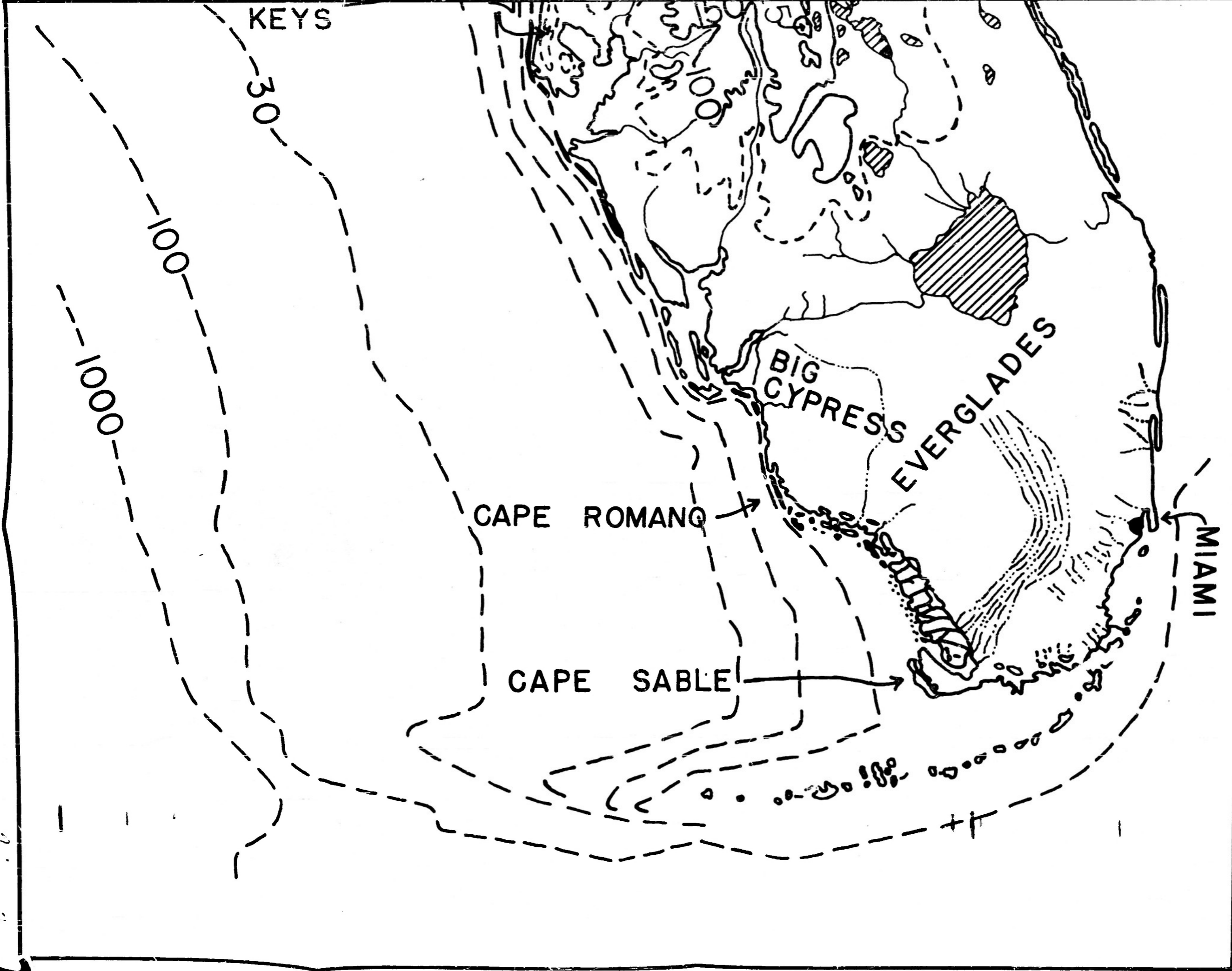
EVERGLADES

CAPE ROMANO

CAPE SABLE

MIAMI

Fig. 3



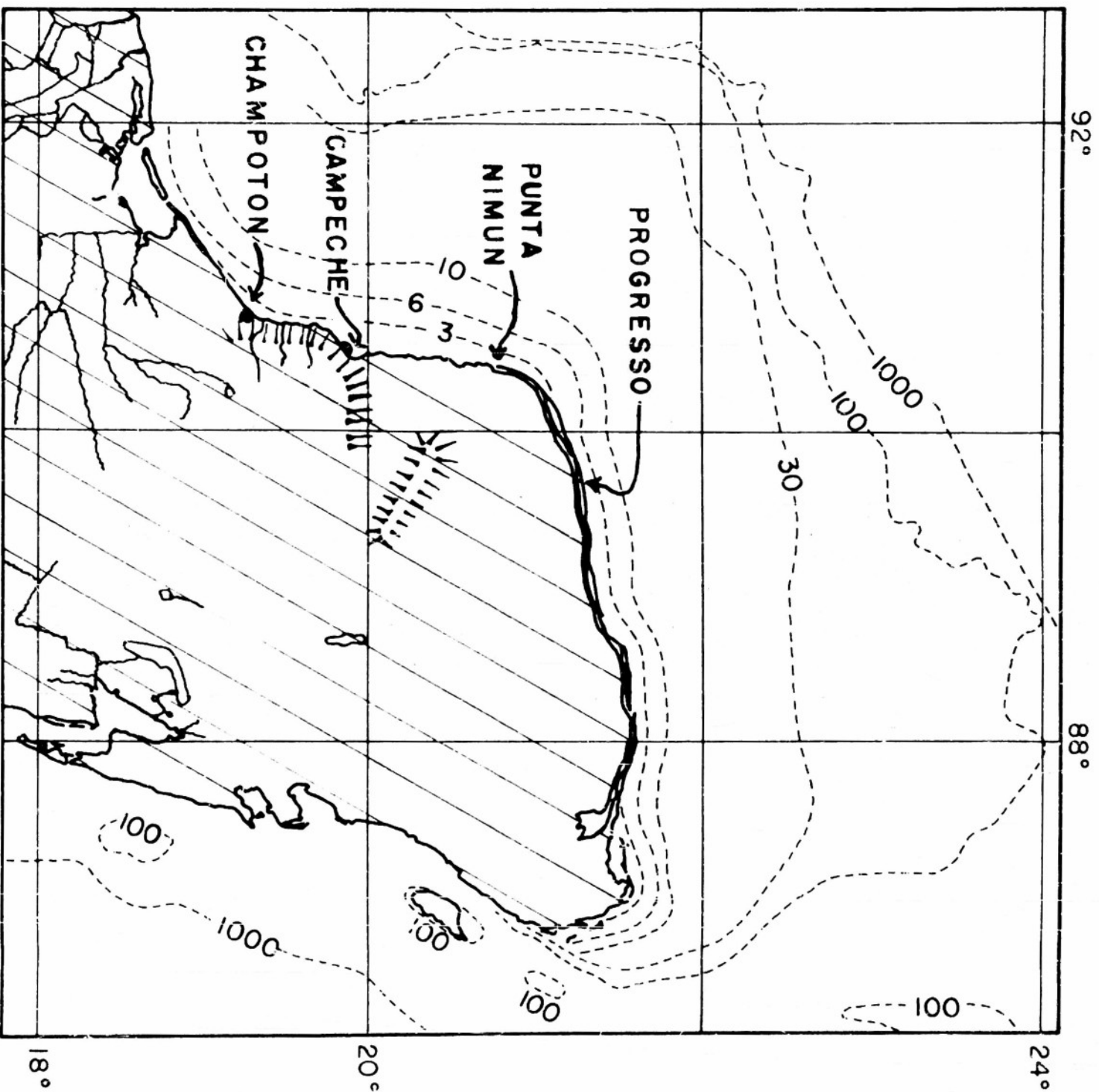


Fig. 3

Florida (Fig. 1, No. 6) sloping 1.0 to 1.5 feet per statute mile in the first 12 miles offshore. The submerged karst relief, with thin deposits of loose sediments in the lows, helps to dissipate wave energy. Absence of strong wave action at the shore here prevents an effective longshore sediment drift ^{2/} from developing and preserves original or contemporarily-

^{2/}

Existence of a coastwise current is not denied.

forming shoreline irregularities, here conspicuous. The types and shoreline conditions of the low-energy coasts studied depend partly on such environmental factors here prevailing as the great width of the continental shelf; the small run-off, sediment-load and clay fraction of a young karst peninsula; the warm, highly saline waters of such an environment under a humid, tropical to subtropical climate, with high production of marl, peat, shells and coral heads; the hard, relatively massive, thick-bedded, gently warped limestones which are fissured and moderately faulted; the dominantly offshore wind regime with moderate onshore storm occurrence, giving a low gross-energy environment.

BEACH-BORDERED COASTS OF MODERATE ENERGY ON THE STEEPER SECTORS OF THE PENINSULAS. Where the original offshore slope in the outer 10 of the in-shore 12 miles seems to have been from 2.0 to 2.5 feet per mile (Fig. 1, No. 4) there is a line of low breakers, shorelines are beach-bordered or bluffed and bottom profiles smoother than on the low-energy coasts. Such moderate-energy coasts and shorelines ^{4/} extend 170 miles from Anclote Keys

^{4/}

Research now going on will give some quantitative values for the degrees of energy used here, but complete numerical evaluation is for the future.

to Cape Romano, Florida (Fig. 2), 200 miles along the entire north shore of the Yucatan peninsula and a fairly high-energy coast with pocket beaches and steep bluffs for 35 miles between Campeche and Champoton on the west coast (Fig. 3).

NEW SHORELINE TYPES OF LOW-ENERGY COAST ^{5/}. 1. Drowned karst shoreline.-

^{5/}

Some are currently described elsewhere (7,8).

Isolated areas in Florida totaling about 75 miles in length, forming coastal outbends of 3 to 4 miles with highly irregular shorelines and standing slightly higher than adjacent marsh and swamp have archipelagoes of low karst elevations with innumerable small peninsulas. The shoreline irregularities are original land features now drowned. The islets are separated by irregular tidal waterways, including: (a) many channels transverse to the coast and usually (b) a well-defined back-swamp coastwise channel between the drowned areas and the mainland (Fig. 4). The karst elevations are tree-covered,

Figure 4. Drowned karst coast and coastwise back-swamp channel.
Chart 1258. Crystal Bay, Florida, 28° 50' N., 82° 40' W.

slightly beveled and rise from 1 to about 6 feet above high tide. Rocky shoals are scattered far offshore on the gently sloping bottom, spring tide ranging from 3.1 to 3.3 feet. This type occurs here and there with the following type.

2. Cross-channeled marsh.- Between and back of the drowned karst areas and standing slightly lower ^{6/} runs a belt of marsh and karst plain totaling

^{6/} R. O. Vernon, oral description of such areas in Citrus and Levy counties, Florida (11).

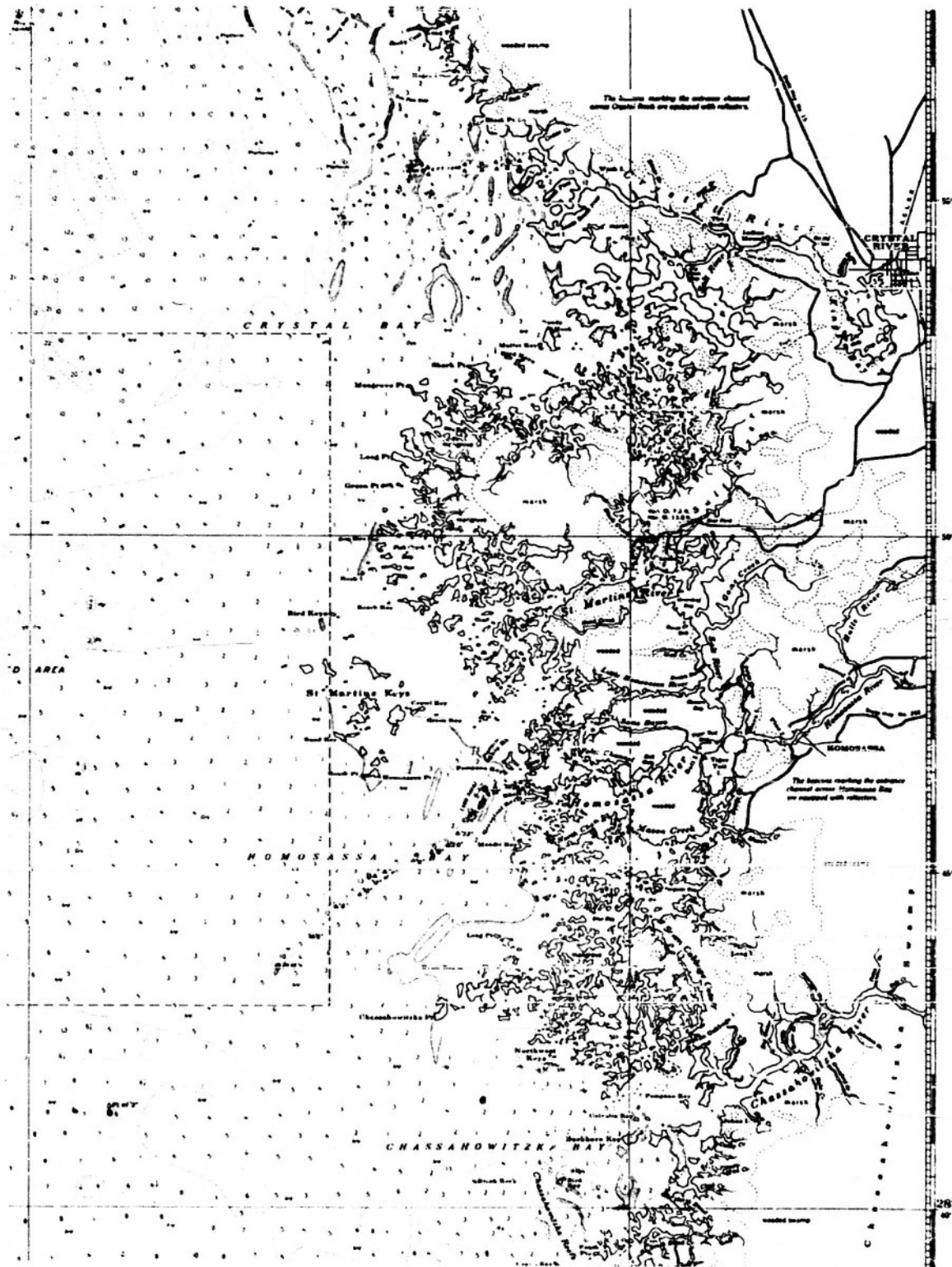


Fig 4

some 110 miles in length between Anclote Keys and Apalachicola delta (Fig. 2). The depressions of the karst are here filled with sand and other sediments and the whole transversely cut by slightly branched tidal channels 0.5 to 1.0 mile long. Linkage of the short branches into a backswamp channel is virtually absent (Fig. 5). The shoreline is less irregular than in the pre-

Figure 5. Cross-channeled marsh, Florida. Chart 1260 at 30° 00' N., 83° 50' W.

ceding type, but a longshore sediment drift is still absent. The shoreline irregularities are of contemporary (tidal) formation.

3. Mangrove barrier ridge and coastal lagoon.— Treatises on the ecology and geological significance of the mangroves (1,2) and papers on the red mangrove (Rhizophora) as a shoreline prograding agent(10) have not described the geomorphic form of the mangrove belt where it develops on a marine shoreline. Probably the greatest developments of this type known are on the 60-mile low-energy sector of Florida (Fig. 2) south of Cape Romano and the 50-mile sector of the Yucatan peninsula between Punta Nimun and Campeche (Fig. 3). The Florida belt is from 5 to 10 miles wide, being widest on the gentlest offshore slope. Its shoreline is highly irregular in places, the irregularities being of contemporary origin.

The marine mangrove belt is cut along its inner margin into a barrier ridge by a nearly continuous, irregular, coastwise backswamp lagoon (Fig. 6)

Figure 6. Mangrove barrier ridge and coastal lagoon, southern Florida, Chart 1113.

with its major widenings where the greater concentrations of inland swamp drainage emerge (3, fig. 71, and personal communication). The front of this flat-topped ridge usually slopes down 6 or 8 feet in a short distance to a

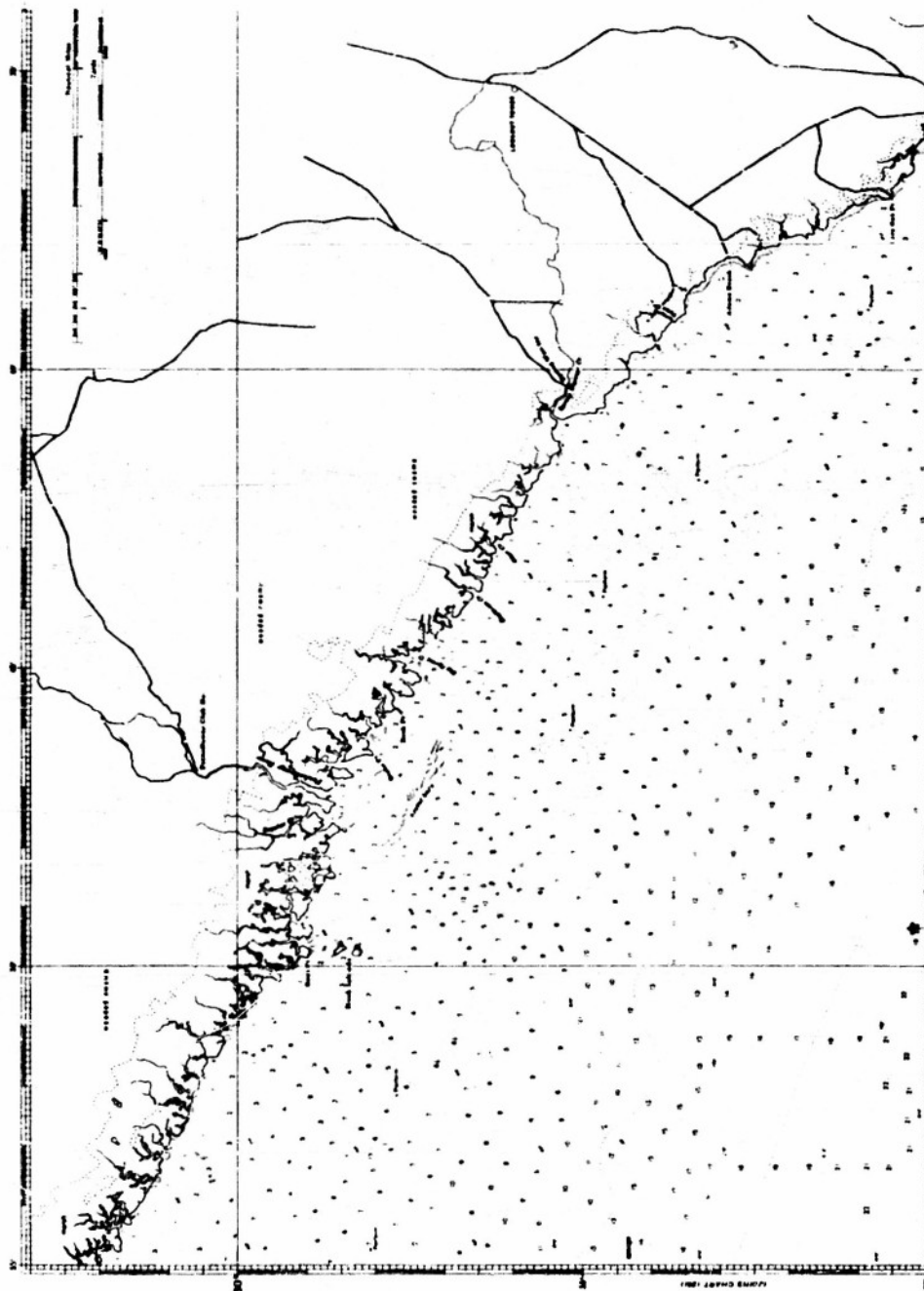


Fig. 5

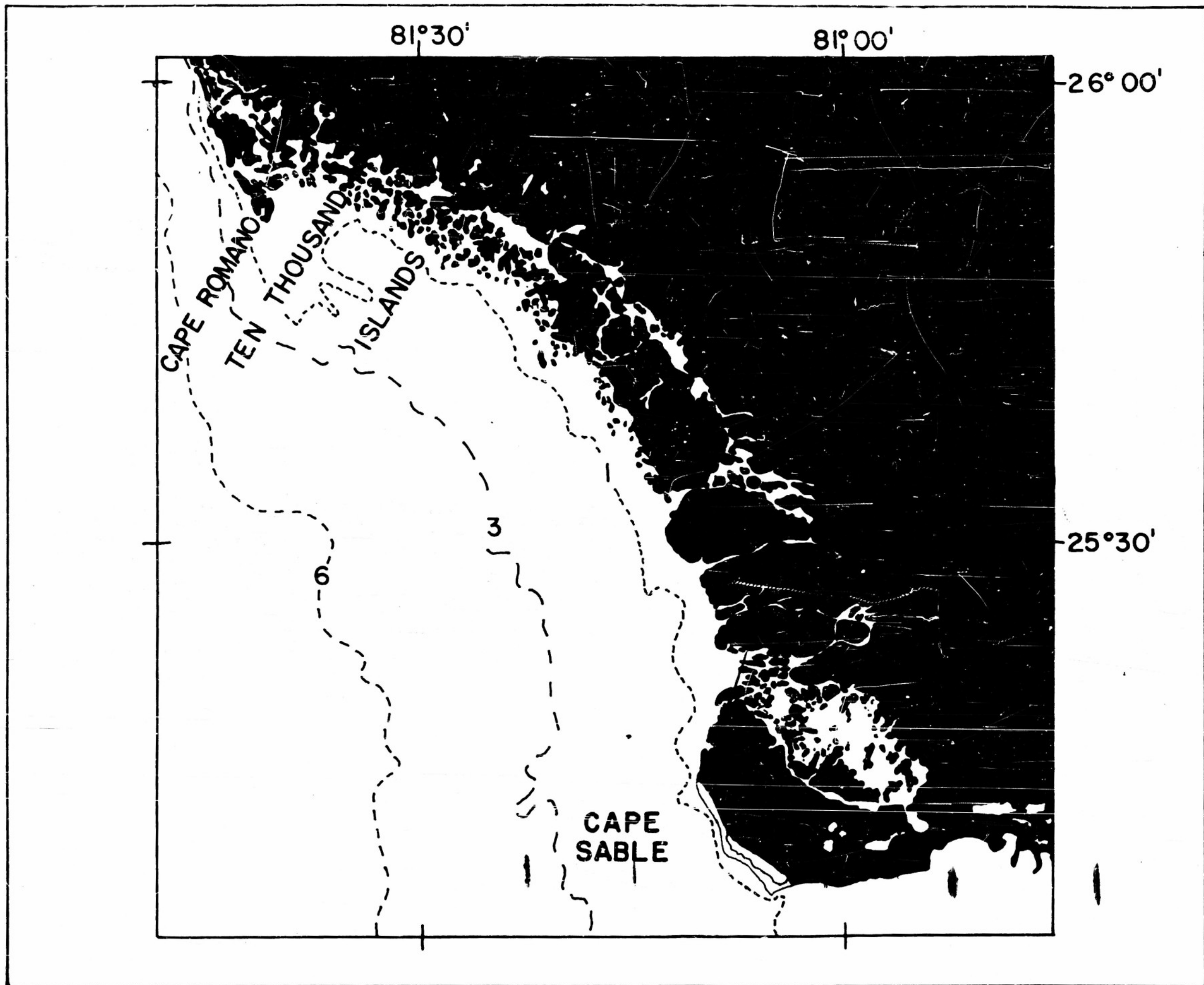


Fig. 6

bare and rocky or sandy bottom. At the inner margin of the ridge, the few soundings show the coastal lagoon to be as deep as 8 feet in places. Mangroves line all shores of the lagoon. Except where the friable, late Pleistocene Miami oolite is near the surface, the swamp trees are rooted in soft marl, in places over mangrove peat. J. H. Davis, Jr. (2) finds that the mangrove belt migrated landward on a slowly rising sealevel from 7.5 feet below lower low tide to its present elevation. It has since prograded 5 to 10 miles during stillstand.

Here and there, disconnected short lengths of low beach ridges of shells or shell-sand and some of Davis' (2, fig. 3) "marl levees" are found at the present marine shoreline or inland in the barrier. These were formed in the tangled forest by storm waters. Marl is actively forming today within the mangrove environment, much of it from lime-depositing algae and diatoms^{2/}.

^{2/} Davis, personal communication.

The writer has seen no evidence here of the expected trapping of marl by mangroves from a longshore sediment drift, such a drift seeming to be inconspicuous or absent. Transverse tidal channels wind through the Ten Thousand Islands archipelago and the more consolidated parts of the mangrove barrier in Florida. Between these channels, the swamp front is relatively smooth southeast of the area protected by Cape Romano and its large southerly bars.

COASTWISE BACKSWAMP CHANNEL. Theoretically, this channel, including the mangrove coastal lagoon, is thought to be the product mainly of tidal scour in soft, water-soaked materials by reversing currents formed when the tide arrives at the back of the swamp or archipelago sooner through some transverse courses than others. Differences in channel lengths, cross-sections

and sinuosities should cause variations in arrival times and tidal heights. The more consolidated and thicker deposits of the cross-channeled marsh have resisted coastwise scour, so that the short branches seldom connect from channel to channel. A few inquiries show that (a) tidal currents occur in the longest of the coastwise channels of the drowned karst, Salt River behind Crystal Bay (Fig. 4) ^{8/}, and that (b) the known rate of

^{8/} C. E. Dawson, oyster biologist; personal communication.

advance of the tide into Apalachee Bay, east of Apalachicola delta, should cause a 0.1-foot difference in height of the water surface and a 0.5-knot current along the 8-mile-by-800-yard channel back of Piney Island ^{9/}. The

^{9/} Rough preliminary estimate by F. C. W. Olsen, oceanographer.

coastwise backswamp channel is the main boundary between fresh and salt waters in the swamp-marsh environment. Contrasts and changes in temperature and chemical nature of the waters may produce alternate deposition and solution along this channel, but it is not predictable at the present where widening, deepening or shallowing should result. More than 185 miles of such channels are mapped in the area of Figs. 2 and 3. In some places, lesser coastwise channel linkages occur on alignments between the backswamp channel and the Gulf. In some deltas, a similar coastwise channel flow may be responsible for striking linkages of winding or meandering abandoned stream channels that might otherwise be closed by sedimentation.

EMERGENT MARINE PLAINS AND SHORELINES OF LOW-ENERGY COAST. On each of the emergent, gently sloping Quaternary shoreline terraces of the drowned karst sector of western peninsula Florida, there is a narrow belt of sand similar

to that just offshore today (11, p. 37, 38). Stabilized sand dunes of the terraces are reworkings of these marine sands, not original shoreline dunes of a high-energy coast, as on the emergent barrier islands of eastern Florida (5). No topographic or depositional evidences of the late, low, Silver Bluff (6, p. 24) stillstands have been identified on the low-energy marine coasts.

The great inland swamps of southern Florida hide any emergent Quaternary mangrove belts that may be preserved there, although they seem to occur in Cuba in lagoons. In Yucatan ^{10/}, air photographs show a single, narrow,

^{10/}

On the peninsula in the state of Campeche.

low-lying terrace just back of the present smooth, moderately high-energy limestone shoreline between Campeche and Champoton (Fig. 3). Inland, no work seems to have been done on emergent shorelines of this peninsula.

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